CAMBRIDGE SYSTEMATICS

TEAMS High-Level Functional Requirements

Functional Requirements Analysis and Implementation Strategy for the Transportation Enterprise Asset Management System (TEAMS)

draft final

technical memorandum

prepared for

Washington DC Department of Transportation

prepared by

Cambridge Systematics, Inc.

with

Dewberry
DataNet Systems

December 8, 2003

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Version 2.0

Table of Contents

List of Tables

List of Figures

Document History

Table 1 Document Tracking

Date	Version	Description
7 November, 2003	1.0	Initial Draft
8 December, 2003	2.0	Responds to specific comments from DDOT Review of initial draft. Added Executive Summary. Expanded Stakeholder Needs section to include more specific DDOT stakeholders. Expanded Services View to include generic process flows for TEAMS applicable to all DDOT administrations. Added Glossary of Abbreviations.

Glossary

AADT	Average Annual Daily Traffic
API	Application Programming Interface
CBT	Computer Based Training
CMD	Curbside Master Database
COTS	Commercial Off-The-Shelf products
DBA	Database Administrator
DDOT	District of Columbia Department of Transportation
DMV	Department of Motor Vehicles
DPW	Department of Public Works
EIS	Executive Information System
EMA	Emergency Management Agency
ESRI	Environmental Systems Research Institute, Inc.
FHWA	US Federal Highway Administration
FRS	Functional Requirements Specification
GUI	Graphical User Interface
GIS	Geographic Information System
GPS	Global Positioning System
HPMS	Highway Performance Monitoring System
IEEE	Institute of Electrical and Electronics Engineers
IPMA	Infrastructure Project Management Administration
ISDN	Integrated Services Digital Network
iSLIMS	Street Light Information Management System
ISO	International Standards Organization
IT	Information Technology
LAN	Local Area Network
MAT	Modeling Advisory Team
MPD	Metropolitan Police Department
NHS	National Highway System
NOC	Network Operations Center

NSDI	National Spatial Data Infrastructure
OCFO	Office of the Chief Financial Officer
OCP	Office of Contract and Procurement
OCTO	Office of the Chief Technology Officer
ODBC	Open Database Connectivity
OSAT	Office of the Director – Operational Support and Applied Technology
PASS	Small Procurement Management
PSMA	Public Space Management Administration
SDE	Spatial Data Engine
SIS	Street Inventory System
SMDS	Switched Multimegabit Data Service
SOAR	System of Accounting and Reporting
TEAMS	Transportation Enterprise Asset Management System
TMS	Traffic Monitoring System
TPPA	Transportation Policy and Planning Administration
TREES	CityWorks Azteca Trees Management Application
TSA	Traffic Services Administration
TSMD	Traffic Signal Management Database
UFA	Urban Forestry Administration
UNETRANS	Unified Network and Transportation
VPN	Virtual Private Network
WAN	Wide Area Network

Executive Summary

TEAMS PROJECT OVERVIEW

The DDOT Transportation Enterprise Asset Management System (TEAMS) Project has been initiated to establish an enterprise approach to data and application integration for asset management at DDOT. TEAMS will consist of:

- A suite of independent asset management applications, operated by individual business units;
- A centrally maintained database of geographic information – "the geodatabase";
- An enterprise data repository linked to the geodatabase;
- A Web Portal for map and report-based views of the enterprise data; and
- Middleware to provide connectivity across the Asset Management applications and between the Asset Management Applications and the central data repository.

Four phases of implementation have been defined for TEAMS:

- Phase I: Feasibility Study and Requirements Analysis;
- Phase II: System Design
- Phase III: System Development; and
- Phase IV: System Deployment and Implementation.

DOCUMENT OVERVIEW

This document is the deliverable for Task 2 (Functional Requirements) of the Phase I TEAMS project. It builds upon the Task 1 report, which analyzed stakeholder needs and existing and planned applications, developed a business case for TEAMS and evaluated off-the-shelf products. It was initially developed based on interviews with TEAMS stakeholders and a requirements workshop, and revised after a review process by the TEAMS stakeholders.

Because TEAMS is a complex project with multiple pieces of software, this document does not follow the traditional software requirements document outline. Instead, it follows an established IEEE standard outline for developing architectural descriptions for complex systems with diverse sets of stakeholders. Its purpose is to crystallize the stakeholder needs established in Task 1, and establish basic architectural principles that address these needs and allow the different components of TEAMS to move forward in a consistent and coordinated fashion in Phase II. Like a traditional requirements document, it

does present lists of assumptions and decisions that can be used to guide the design process and determine whether the design is responsive to established requirements.

Four views of the system are established – the Services View, which describes what TEAMS will do; the Data View, which describes data management mechanisms; the Construction View, which covers the system's building blocks and interconnections, and the Deployment View, which addresses implementation concerns. The focus of the document is on the initial two views, given the need to focus on business owner needs at this phase of the project.

SERVICES VIEW

The Services View establishes requirements to support the following key stakeholder needs:

- Provide consolidated view of assets and events related to selected locations, with drill-down capabilities;
- Support work flow coordination across business areas through automating information flow across systems and establishing centralized status tracking and work history recording methods;
- Facilitate federal reporting through automating production of required reports that draw upon data maintained at the enterprise level or from multiple business units, with the HPMS report being the most critical need;
- Meet executive information needs through provision of high-level reports that consolidate information to provide summaries of activities, performance and exceptions; and
- Provide efficient data entry, updating and validation mechanisms, including automated updating of data in the TEAMS central repository based on changes made in individual asset management applications, as well as updating of enterprise data used within asset management application.

DATA VIEW

The Data View addresses mechanisms for data sharing across the enterprise. It includes requirements for:

- Management of geospatial data, and coordination of this data with asset management system data;
- Establishment of a central TEAMS data model and data dictionary, including standard coding schemes that allow for consolidation of similar types of data across systems as well as "roll-ups" of information to meet executive and manager needs;

- Establishment of metadata services to allow users to understand and interpret the enterprise data that is being made available to them;
- Support for versioning of data, including historical views of information;
- Establishment of an enterprise-level data collection, updating and validation plan; and
- Provision of linkages to data maintained in external applications (e.g. OCTO, DMV).

CONSTRUCTION VIEW

The Construction View defines the building blocks of TEAMS, and presents current thinking as to which will be provided via off-the-shelf components, and which will require custom development. Off-the-shelf components will include:

- GIS data management, mapping and analysis tools provided in the ESRI product suite;
- Commercial reporting package with both web and desktop capabilities;
- SeeBeyond middleware;
- Individual asset management applications – new applications will be required to meet specific criteria to ensure compatibility with the middleware, supported databases, georeferencing methods, and software architecture. The requirements call for the capability to incorporate existing windows-based legacy applications into TEAMS on an interim basis, even if they do not meet the criteria for new applications.

Custom development will likely be required for the GIS data maintenance sub-system, for building the GIS query and reporting application (to be accessible from web and desktop clients), and for providing specialized capabilities in support of data validation and reporting (including a GIS-based HPMS application). In addition, considerable effort will be required to build business rules and define specific queries and data transformations for the SeeBeyond middleware.

DEPLOYMENT VIEW

The Deployment View covers both technical issues related to installation, support and maintenance of TEAMS components, as well as organizational and process issues related to implementation of a system of this nature. While it is clearly early in the TEAMS development process, it is useful to identify these deployment issues now, so that the Task 3 project plan can ensure that all important activities are taken into consideration. Key deployment concerns include:

- Need to recognize and plan for business process changes required for an enterprise data sharing approach;
- Need to establish ongoing mechanisms for stakeholder involvement in all phases of the TEAMS project – to help stakeholders understand how TEAMS will affect them, to ensure that the stakeholders have an opportunity to participate in key decisions, and to keep them informed about the status of the project;
- Need to build in sufficient budget and attention to initial and ongoing user training and support needs;
- Need to plan for additional investments in hardware to provide sufficient storage space for the data, ensure that the data are kept secure and ensure that the system can be scaled up to meet likely future needs;
- Need to plan for additional database administration, system administrator and system support effort; and
- Need to develop data migration, installation and roll-out plan.

1.0 Introduction

1.1 TEAMS OVERVIEW

The mission of the District of Columbia government Department of Transportation (DDOT) is to enhance the quality of life for District residents and visitors by ensuring that people, goods and information move efficiently and safely, with minimal adverse impacts on residents and the environment.

As part of its mission, DDOT has initiated the Transportation Enterprise Asset Management System (TEAMS) project to provide interoperable business functions and enterprise solutions to the following five administrations within DDOT: Infrastructure Project Management (IPMA), Traffic Services (TSA), Transportation Policy and Planning (TPPA), Urban Forestry (UFA), Public Space Administration (PSMA), and other business units: the Office of the Director – Operational Support and Applied Technology (OSAT), the Office of the Chief Financial Officer (OCFO), the Office of Contract and Procurement, and the US Federal Highway Administration (FHWA).

TEAMS will provide an integrated approach to management of asset-related data throughout the District of Columbia Department of Transportation (DDOT). TEAMS will consist of a suite of data maintenance and asset management applications, a central data repository for management of geographic and attribute data, a web portal providing enterprise access to data, and middleware which provides connectivity and interoperability between asset management applications and from the asset management applications to the central repository.

1.2 SYSTEM JUSTIFICATION

DDOT has initiated TEAMS in order to achieve the following essential DDOT business objectives:

- Improving or enhancing business processes for asset management and decision making. This involves:
  - Improving coordination of work across different business units responsible for the same assets.
  - Making timely and accurate information about asset condition, and characteristics, and capital project or maintenance work activity status, available in a highly accessible fashion to DDOT decision-makers and individuals responsible for interagency liaison and communication with the public.

  - Developing a strong, credible base of integrated information to enable better decision-making with respect to priority-setting, asset maintenance standards and policies, and optimal means and methods for work.
  - Facilitating performance measurement and management reporting functions; both by further automating reporting of existing performance indicators and also potentially making new, more meaningful indicators available (through integration of information from disparate sources).
  - Facilitating the efficient and accurate preparation of external reports that draw upon a variety of sources (e.g., HPMS).
- Facilitating data sharing within and across DDOT's business administrations.
- Migrating existing stove-pipe spatial and attribute data into an enterprise-wide integrated manageable system.
- Promoting technology upgrades within DDOT by using cutting-age information technology, relational database management systems and web technology.

A variety of applications are already in place or under development which provide functionality to meet the needs of individual business units. TEAMS will provide the enterprise-wide infrastructure to enable sharing of data across units, and integration of applications. This is expected to result in substantial improvements to both efficiency and effectiveness in activities related to design, construction, maintenance, and operations of the District's transportation assets.

The improved transportation information provided by Geographic Information System (GIS) and related technology solutions will help the District achieve its vision of a safe, efficient and economical transportation system that is managed by making investments and system improvements that are balanced, comprehensive and coordinated to achieve the greatest value and minimal disruption for District residents, businesses and visitors.

The TEAMS effort is being led by OSAT. Representatives from all five DDOT administrations and the Office of the Director will use TEAMS, and are participating in the TEAMS development process.

1.3 PURPOSE AND SCOPE OF THIS DOCUMENT

This document is the deliverable for Task 2 of the Phase I TEAMS project. The objectives of Task 2 are to "establish a set of formal functional requirements that will serve as the basis for designing and developing TEAMS." Traditionally, a functional requirements specification (FRS) serves as a kind of contract between the users of a system and the designers and developers of that system. The process of developing an FRS involves articulation and documentation of needs from the stakeholders affected by system implementation, resolution of conflicting requirements, and also establishment of priorities in order to ensure

that the system scope is realistic given available resources. The FRS serves as the blueprint for the system designers and developers.

Because TEAMS is a large and complex project involving not a single system, but an interrelated set of system development activities, the requirements analysis for Phase I is being conducted at a high-level. Its purpose is to crystallize the stakeholder needs documented in Task 1, and establish basic architectural principles that address these needs and allow the different components of TEAMS to move forward in a consistent and coordinated fashion in Phase II. Given this objective, this document does not follow a typical FRS outline, but uses a Technical Architecture Description[1] outline instead. More detailed FRS documents for individual system components will likely be required as part of Phase II.

1.4 AUDIENCE

The audience for this document are the stakeholders identified for the TEAMS project. These include potential users of the system and providers of data in all five DDOT administrations (IPMA, TPPA, TSA, PSMA, and UFA) and the Office of the Director, as well as information technology professionals within OSAT who will be managing TEAMS development, implementation and support.

1.5 DOCUMENT ORGANIZATION

Section 2 identifies the key TEAMS stakeholders and summarizes their needs.

Section 3 presents TEAMS requirements from four points of view – Services (functions to be provided), Data (contents), Construction (building blocks and connectivity), and Deployment (infrastructure, support services and business process changes for TEAMS implementation).

Section 4 tracks comments and issues regarding TEAMS requirements, and how they have been resolved.

1.6 RELATED DOCUMENTS

The following documents are pertinent to this effort:

[1] This document conforms to IEEE-Std-1471. An "Architectural Description" of a system is concerned with the interrelationships among the system's components and the fundamental principles governing its design and evolution. An overview presentation for this standard may be found at http://www.incose.org/delvalley/Hilliard_11_14_00.pdf.

1. TEAMS Statement of Work – "Functional Requirements Analysis and Implementation Strategy for the Transportation Enterprise Asset Management System (TEAMS), District of Columbia Department of Transportation, Operational Support and Applied Technology, April 2003.
2. "DDOT Transportation Data Model and Street Spatial Database Development", presentation to the 23rd International ESRI User Conference, Ali Fatah and Minhua Wang. July 10, 2003.
3. Cambridge Systematics, Inc., "TEAMS Feasibility Assessment", prepared for District of Columbia Department of Transportation, October, 2003.

2.0 Stakeholder Needs

TEAMS requirements were developed to respond to the needs of a variety of stakeholders, both within DDOT and external to DDOT. Stakeholders groups are defined in section 2.1. Section 2.2 summarizes the needs of each group.

2.1 TEAMS STAKEHOLDERS

Internal Stakeholders

Four general categories of internal TEAMS stakeholders have been identified for purposes of this high-level requirements document:

- End-Users, including Power Users (those who will be entering data into TEAMS and/or obtaining information from TEAMS on a daily basis) and Casual Users (those who will use TEAMS occasionally, or who will receive information from TEAMS indirectly from others). Power Users are further distinguished by whether they are primarily contributors of information, consumers of information, or both. Specific groups of DDOT end users with distinct needs include:
  - Engineers
  - Operational managers (project managers)
  - Senior managers (executives)
- System Developers and Integrators – those who will be responsible for overseeing the development of TEAMS and integration of its components with existing systems.
- System Support and Maintenance Staff – those who will have ongoing responsibility to support TEAMS, ensure that it operates smoothly, and respond to any changes – both technical and organizational that require system adjustments.
- System Deployers– those who will be responsible for installing TEAMS, transitioning existing systems and data, and training DDOT staff in how to use TEAMS components.

Within DDOT the following specific groups will participate in multiple roles as end-users, and in the development/integration, support and maintenance and deployment of TEAMS:

- OSAT - Spatial Data Systems
- OSAT - Applications and Applications Support
- OSAT - Program Management Office (PMO)

External Stakeholders

External to DDOT there are several stakeholders who are primarily end-users including:

- Other DC Agencies (e.g. Mayor's Office)
- Federal Agencies (e.g. Federal Highway Administration)
- Citizens

In addition, the Office of the Chief Technology Officer (OCTO) is likely to play a support role in system deployment with respect to network bandwidth and security issues. OCTO is also a source of GIS data for TEAMS.

2.2 STAKEHOLDER NEEDS SUMMARY

Internal Stakeholders

End Users – Power Users

TEAMS power users who are consumers of information need to know what information is available via the TEAMS repository, and how to access it in a variety of formats – standard reports, maps, spreadsheets, etc. They need the flexibility (and training) to create new types of queries, or to request new queries from IT staff and get quick response to these requests. They need to be able to assess the source, quality and currency of the information they are obtaining.

Those responsible for providing information need this process to be as straightforward and efficient as possible. They would like to minimize the need to enter any given piece of information more than once. When entering location information, they need to have appropriate tools to facilitate this process (e.g. map-based displays, GPS recorders). They need to understand how the information they are entering will be used. They need to have an opportunity to verify and confirm the accuracy of the information they have entered. They need to have the capability to make corrections to already entered information.

Within DDOT, two types of power users can be distinguished - Engineers and Operational Managers:

- **Engineers** will be TEAMS information providers as well as consumers. Much of their interaction with TEAMS will be via the individual specialized asset management applications that support specific activities (e.g. pavement management, maintenance management, traffic monitoring, accident analysis, capital project development, etc.). They will make use of the middleware and central repository elements of TEAMS in order to obtain access to enterprise information that is not being directly maintained in the asset management system(s) that they currently have access to. In general, engineers will make use of TEAMS information to gain a better

understanding of problems or needs, and to assist with making an informed decision about how best to address a problem or need (when, where and how). Therefore, engineers need accurate and timely information, generally at the most detailed, disaggregated level. They need to be able to obtain this information via flexible query capabilities, and save the results of these queries to a variety of formats so that they can be analyzed further and incorporated into documents. They also need to be able to save specific queries they have done for future use.

- **Operational Managers**, like engineers, will also be interacting with individual asset management applications geared to their specific needs. Their needs will overlap somewhat with those of engineers, in that they may wish to query specific technical details pertinent to a problem or project. However, they will be more concerned with automation of work flow across systems, easy access to standard reports showing summary-level information, ability to generate exception reports meeting specified criteria, and drill-down capabilities for exploration of specific problems or issues.

End Users – Casual Users

Casual users need an intuitive user interface that they will remember how to use from session to session. They need easy access to standard reports and maps that meet their business needs. They need to understand the source and quality of the information they are obtaining.

Within DDOT, Senior Managers will be casual users of the system. They will directly access a relatively small number of standard summary-level reports/maps presenting high-level management information on performance measures and activity status. They will also need to understand what type of information is in TEAMS in order to make more specific requests to staff for custom queries, reports and maps.

System Developers and Integrators

System developers and integrators need to minimize risks and maximize efficiency of the system development process. They want to make use of already in-place systems where feasible to avoid disruption and make the best use of available resources. Where new functionality or technology upgrades are required, they seek to identify off-the shelf components that:

- fit with identified business requirements;
- can be easily customized to meet identified needs, or do not require substantial customization;
- have proven reliable in similar settings;
- have a well-understood upgrade path and are likely to be supported by the vendor for the foreseeable future;

- have licensing fees in line with available resources and the value added;
- will operate within DDOT's hardware and software environment; and
- can be connected to other components at a reasonable level of effort.

For elements requiring custom development, system development staff need to ensure that existing standards are followed – with respect to software tools, interface design, coding, data modeling, documentation and quality (e.g. ISO 9000). They also need to ensure that a "test bed" is available during the development process so that production software and data can be operating separately from test software and data during the development process.

System Support Staff

System support staff need to understand the big picture of how the system works, including system components, data flow, work flow and end results.[2] They therefore need accurate and informative documentation of TEAMS architecture, components, process flow and data models. They need the various elements of the system to be as reliable as possible so that issues are kept to a minimum. They also need training programs and other efficient user information dissemination mechanisms in place. Their job is made easier when the system consists of relatively few, rather than many individual components; and when they have relatively few (rather than many) outside vendors and/or software developers to deal with. They need to minimize ambiguity as to the solution to a given end-user problem (e.g. COTS asset management system vendor? Middleware vendor? Middleware developer? Database Administrator?). They need access to accurate documentation for all system elements, as well as access to appropriate experts – both external and internal to DDOT.

System Deployers

System deployers need to ensure that the hardware and software infrastructure requirements of TEAMS are consistent with available infrastructure and resources for expanding those resources. These include servers; client computers; telecommunications equipment; network bandwidth; and licenses for operating system, database and application software. They also need to ensure

[2] Figure 2 in reference [3] provides a more detailed view of the proposed TEAMS software architecture and the system components. The Spatial Data Services staff are currently updating this diagram, and have also sketched out the geodatabase model for TEAMS, which outlines the spatial data and key attributes from the various applications that will be replicated in the central GIS data repository. These documents, together with the Network Systems diagram depicted in Figure 3.1 below, provide a high-level overview of the TEAMS architecture and system requirements. More detailed data flow diagrams and work flow process diagrams will be required as part of the detailed design in the next phase of the project.

that software installation requirements are straightforward and not overly onerous, for both end users and IT staff. Finally, they need sufficient resources and materials to adequately train different types of system users as different portions of the system come on-line.

OSAT – Spatial Data Systems

A special mention is made for the Spatial Data Systems (SDS) staff in OSAT because of the key role they will play in the TEAMS system design and implementation. They will guide the development of the GIS central repository and the TEAMS web portal and ensure the quality and integrity of the spatial data. Currently, as part of their responsibilities they manage the transportation data layer for the District (integrated by OCTO), and this will continue to be an important function as TEAMS is deployed and more applications reference their data to the GIS centerlines. The Spatial Data Systems staff also manage the SIS block ID's in GIS, which will become another important method for referencing business data. At the core of TEAMS will be a geodatabase model that manages the relationships between the spatial and attribute data and supports several location referencing methods. This requires that all business data to be included in TEAMS must use one of the approved location referencing methods. The Spatial Data Services staff will need to maintain their knowledge of the GIS system and its associated components, and advise the system developers on spatial data formats, data standards, metadata, geodatabase design, GIS coding and programming standards, and provide general GIS technical support as needed. Therefore, maintaining a strong and committed Spatial Data Services staff is critical to the success of the TEAMS project.

External Stakeholders

Outside of DDOT, a variety of DC and federal agencies will be casual users of the system:

- Within the DC government, a variety of agencies are potential users of TEAMS information or possibly contributors to TEAMS. These include the Mayor's Office, the Department of Public Works (DPW), the Water and Sewer Authority, the Office of the Chief Financial Officer (OCFO), the Office of Planning, the Emergency Management Agency, and others. These agencies will have an interest in viewing maps showing transportation asset characteristics and associated planned and historical projects.
- The Federal Highway Administration (FHWA) is a very important TEAMS stakeholder. While FHWA is not anticipated to be a major daily, hands-on user of TEAMS, it will be a key recipient of a great deal of information derived from TEAMS. From FHWA's viewpoint, TEAMS needs to provide a solid infrastructure for effective asset management practices within DDOT, and it needs to be the source of timely and accurate information on federally-funded highway projects. It must facilitate preparation of required federal

reports, primarily for those related to highway information (e.g. highway statistics, mileage certification, HPMS, traffic monitoring).

- Other federal and regional Government agencies likely to be either requesters of TEAMS data, providers of data to TEAMS or occasional users of TEAMS query capabilities include the Metropolitan Washington Council of Governments (MWCOG), the National Capital Planning Commission (NCPC), the Architect of the Capital, and the Washington Metropolitan Area Transit Authority (WMATA).
- Other non-government organizations, utility companies, contractors and neighborhood groups have an interest in viewing maps of DDOT highway assets, accessing information on asset characteristics (e.g. street and sidewalk dimensions), and utilization characteristics (traffic counts, accident rates), checking the status of planned construction and maintenance activities, and querying historical activities.
- Citizens have an interest in viewing a variety of information that will be part of TEAMS, including planned projects and their status, dates of prior activities (e.g. when a particular road was last paved), results of special studies, traffic volume and accident data, and summaries of maintenance activities performed. Citizens may address specific requests or comments via the Mayor's Call Center; those requests related to DDOT will be processed by the work flow automation elements of TEAMS. Thus, TEAMS will facilitate the flow of work request and work status information across disparate systems, including the Hansen system and the SERVES correspondence system.

3.0 Architectural Views

3.1 VIEWS FOR TEAMS ARCHITECTURE

Based on the stakeholder needs, the following four views for TEAMS have been identified:

- Services View – functional capabilities – what the system will do.
- Data View – data structures and data management mechanisms.
- Construction View – system structure - components and interfaces, development platforms and tools.
- Deployment View – data migration, system transition, system operations, hardware and networking requirements.

For each view, the following sections are provided:

a. Purpose and Scope - *What's in, what's not in, this view?*

b. Key Concerns - *What are the architectural drivers- links to the stakeholder needs - leading to the decisions made in this view?*

c. Assumptions - *Any givens, including decisions outside the scope of this view, that influence the decisions here.*

d. Key Decisions - *Overview of the key decisions. These are the 'contractual obligations' of the view – commitments ("will do"), obligations ("shall do"), and freedoms ("may do").*

e. View Model - *The graphical model(s) capturing the view, using selected notations.*

While it is important to consider all four views in developing requirements for TEAMS, the Services and Data views are most relevant to business end users, and are the most important views at this stage of the project.

The information in this section is based on the stakeholder needs analysis conducted for Task 1 (reference [3]), and a stakeholder requirements workshop held on October 30, 2003. It was revised based on comments made at an internal DDOT workshop on November 20, 2003.

3.2 SERVICES VIEW

Purpose and Scope

The Services View is concerned with what TEAMS will do. Since TEAMS is not a single system, but rather an integrated approach to data sharing and work flow coordination, the Services View does not emphasize the functions of individual

asset management systems to meet individual business owner needs. The focus instead is on the functions of TEAMS that will provide users with information integrated from multiple sources, and the functions of TEAMS that will provide connections across applications to facilitate work flow coordination.

Key Concerns

Stakeholder concerns with respect to TEAMS functionality can be grouped into 6 categories, which are summarized below.

Provide consolidated view of assets and events related to selected locations, with drill-down capabilities

Both casual and power users of TEAMS want the capability to select a location on a map (street segment, ward, route), and see a variety of information pertaining to that location, including[3]:

- Asset location, characteristics and condition (including identified deficiencies)
- Route classification (e.g. functional class, NHS, snow plow routes, school bus routes)
- Street configuration and operational characteristics (e.g. # lanes, direction)
- Traffic & Safety (e.g. AADT, crash rate)
- Work requests
- Permits
- Utility construction plans
- Work history by work type & asset
- Planned and active capital projects (including local & federally funded, signal and street lighting work)
- Curbside regulations
- Underground utilities
- Zonal or polygon data (e.g. zoning, flood-prone areas, historic districts)

Users want the ability to drill down to further levels of detail from information seen on the map including the following:

- Park Services – DC and National
- Right of Way

[3] See Reference [3] Table 2 for further detail on enterprise data needs in each category.

- Bridge History
- Historic District
- Trees
- As-Built Drawings
- Third Party liabilities for damaging DC properties

Support Work Flow Across Business Areas

Power and casual users of TEAMS want to facilitate work flow and make timely status information available for processes involving multiple business units. Desired functionalities here are automated creation of requests for action, electronic sign-offs, queries to see where a particular issue is and who it is currently assigned to, automated alerts when a particular event occurs, and automated transfer of responsibility to supervisors if there is no action taken within a certain amount of time. Specific processes include:

- Response to citizen inquiries/complaints – Recording the complaint, notifying appropriate parties, assigning responsibility for the complaint, determining what is needed to respond, recording work done to respond, communicating back to the customer, closing the request, performance reporting.
- Response to internally-generated issues (tracking work flow across different units).
- Capital project budgeting and approvals – Project initiation (neighborhood planning, special studies), scoping, estimates, financing plan, priority-setting, programming.
- Design/Construction management – hiring design consultant, design approvals, bid preparation, advertisement, bid award, daily work tracking, payment, change orders, inspections, close-out.
- Maintenance management – work orders, inspections, notifications to other units.
- Neighborhood transportation/traffic calming study punch list tracking.
- HPMS reporting work flow – data input, validation, correction, report generation, checking, submittal.

Meet Federal Reporting Requirements

TEAMS users want to automate the production of required federal reports that draw upon data maintained at the enterprise level (e.g. location, street lengths) or from multiple business units. These include the HPMS report, highway statistics reports and the mileage certification report. Federal reports related to events occurring in the design, construction and maintenance (e.g. design

exceptions, bid opening/tabulations, changes and extra work) need to be considered as part of work flow automation within and across individual asset management systems.

Meet Executive Information Needs

DDOT executives (associate directors and unit supervisors/managers) want the TEAMS effort to provide efficient access to summaries of activities and performance, and exceptions. They also want the ability to drill-down to more specific information based on the higher-level summaries they review. Specific needs include:

- Weekly performance report automation
- Roll-ups/tabulations of service requests by type and status
- Financial information – available and obligated dollars by category, programmed projects and their status
- Projects with change orders exceeding a threshold
- Work requests open over a certain threshold time period
- Work flow delays (e.g. event in a given status for more than a certain amount of time)
- Summaries of responses to past events in a form helpful to understanding requirements of similar future events, e.g. expenditures by activity type associated with hurricanes.

Provide efficient data entry, updating and validation mechanisms

TEAMS power users responsible for data input want to minimize the time required for data input tasks. Electronic recording of data as close as possible to its source is the objective. In addition, opportunities to consolidate data collection activities where similar types of information is being collected by different units should be explored in order to reduce overall data collection costs.

All TEAMS users want to ensure that the data in the TEAMS asset management systems and central repository is accurate and timely. Data validation routines that produce reports of anomalies, mapping capabilities (which can greatly assist in identifying data errors), and work flow support for data update and review cycles are all features that can address data quality concerns.

Provide intuitive and simple user interfaces

TEAMS users – particularly casual users need user-friendly interfaces to access the data, similar to web navigation tools with menus and easily interpreted icons.

Assumptions

1. End users will access the TEAMS central repository of information via a web portal, which will include both map and tabular displays. They will also be able to access this repository via a thick GIS client.
2. Specialized, production-quality maps will be produced using a thick GIS client. OSAT Spatial will continue to provide mapping and spatial analysis services to business units.
3. Existing systems supporting data entry, analysis and reporting functions specific to individual business units will continue to be owned and managed by these business units. However, as these systems are upgraded and as new systems come on line, business units will coordinate with OSAT to ensure that these new / upgraded systems are compatible with TEAMS.
4. Data loaded into the GIS Repository will be spatially enabled in the geodatabase, rather than in local databases. Some of these local databases and applications, for example the CityWorks Azteca Trees application, have developed their own map GUI's in GIS. This is compatible with the TEAMS architecture. In this example, UFA staff may prefer to use the Trees application interface, especially if they have been trained on how to use it, while other non-UFA users who wish to query the Trees database would use the web map interface to the GIS Repository.

Key Decisions

1. TEAMS Web Portal shall include the following types of standard reports and queries:
    - » Weekly / monthly performance report by administration
    - » Asset summary by ward: mileage, # bridges, # culverts, etc.
    - » Monthly activity summary by ward: potholes filled, lane-miles resurfaced, etc.
2. TEAMS Web Portal shall allow a user to select a map location and view the following types of data for that location:
    - » Asset quantity and condition summary
    - » Crash statistics summary
    - » List of accident records
    - » AADT
    - » List of programmed capital projects
    - » List of completed capital projects
    - » Maintenance work history
    - » Open work requests by type and status

- » Permits by type and status
- » List of pertinent studies

3. TEAMS Web Portal shall support thematic mapping including:
   - » Assets by condition classification, age classification, type, years since last treatment (different categories to be defined for pavements, bridges, culverts, signs, lights, etc.)
   - » Streets by AADT range, # lanes, functional classification
   - » High accident locations
   - » Capital projects by status and year
4. TEAMS Web Portal may provide drill-down capabilities to allow the user to access the following:
   - » Special studies or reports
   - » Individual accident reports and intersection diagrams
   - » Bridge inspection reports
   - » Design drawings / As-built drawings
   - » Work request detail
   - » Capital project detail
   - » Project history detail
5. TEAMS shall replicate data from individual asset management applications into the central repository. Options shall be provided for immediate replication (triggered by updates), scheduled replication (e.g. nightly), or on-demand replication. If real-time, on-demand information is required, the application has to trigger the geodatabase to transfer data through ODBC protocols.
6. TEAMS Web Portal may support live access to detailed documents from the future FileNet repository.
7. TEAMS Web Portal may support live access to individual asset management databases for detailed queries of data not stored in the central repository.
8. TEAMS Web Portal may support linkages with other web-based asset management applications.
9. TEAMS Web Portal may allow users to customize their “home” page.
10. TEAMS may include the capability to coordinate work flow and data updates across different asset management / work management systems. The following types of coordination mechanisms may be implemented:
    - » Updates to TEAMS repository based on changes to enterprise information in individual asset management systems.

- » Update to Pontis roadway information as SIS street and AADT data is updated.
- » Update to pavement management data from master SIS information (including AADT, block length).
- » Mayor's Customer Call Center – requests related to signals, lights, curbside shall trigger a request in the related system. Resolution recorded in individual system shall trigger status update in Call Center database.
- » Alert via email or record to inspections management system on completion of construction work;

11. The TEAMS Web Portal may include a set of pages for presentation of TEAMS data to the general public.

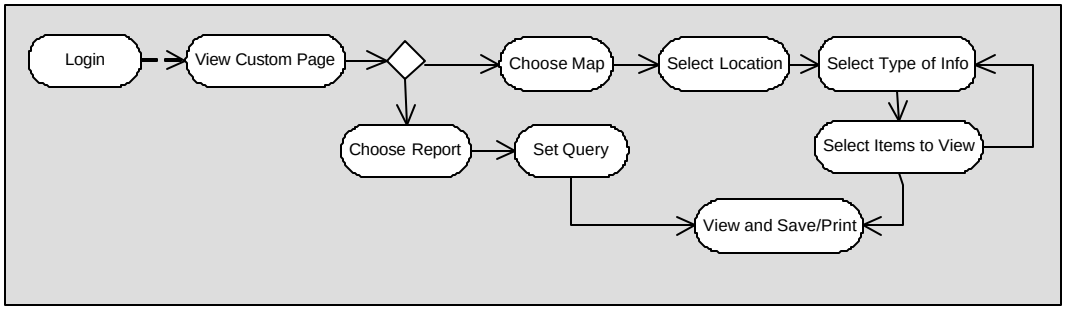
View Model

The view model for Services includes activity flow diagrams for the generic processes that TEAMS will support across all DDOT administrations: work flow support; coordination across asset management applications; updates to the TEAMS data repository from asset management applications; use of the TEAMS web portal for mapping and reporting, and production of federal reports utilizing GIS tools and the TEAMS repository.

Process #1: Accessing Enterprise Data Using TEAMS Web Portal

This first process flow illustrates use of the TEAMS Web Portal for exploring enterprise data. The flow diagram shows a user logging in to the Portal, and viewing a page that has been customized for them. The user would choose to either go directly to reports or to access data from a map view. From the report list, they would select which set of data to query (e.g. show me a work history list for pavement sections with condition = poor), and then view and print the report. From the map view, the user would have tools for zooming and selecting a location of interest. They would then select what type(s) of information to view for that location (e.g. project history, pavement condition, traffic data, list of special studies, etc.). In some cases, they would see a further list of available data so that they could select what to view (e.g. list of PDF's with studies of interest for the geographic area). In other cases, the information would be shown on the map (e.g. a thematic map showing pavement condition. The scenario below illustrates use of the Portal for accident investigation.

Figure 1 Accessing Enterprise Data Using TEAMS Web Portal



Scenario 1: Use of the TEAMS Web Portal for Accident Analysis

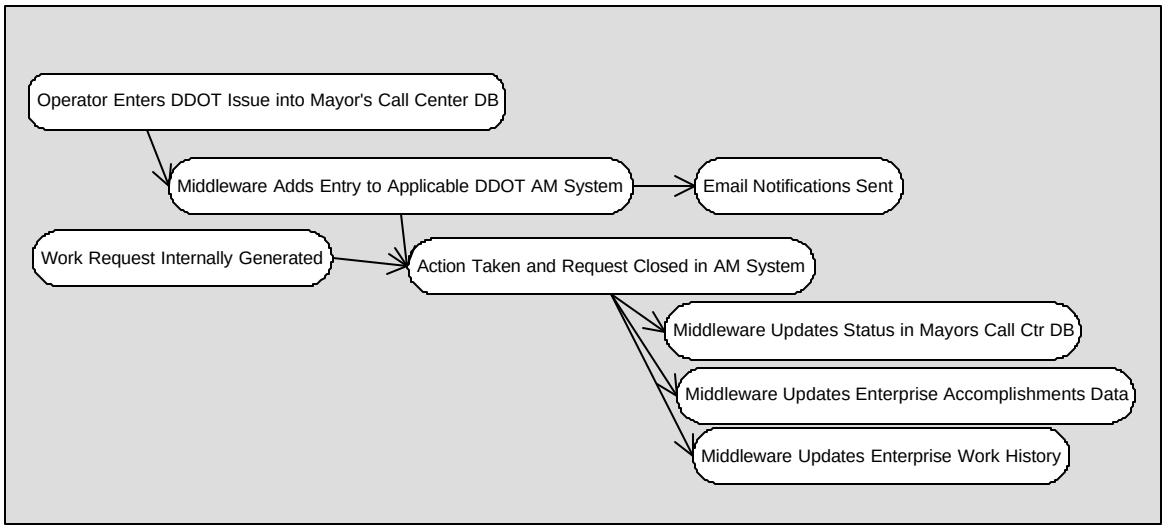
1. The TEAMS repository is automatically refreshed (via SeeBeyond) when new accident records are entered into the safety management / accident reporting system. Similarly, the repository is refreshed as projects are completed and as changes to the status of planned projects occur.
2. A fatality occurs at an intersection, and an analyst is assigned to investigate past trends, issues and future plans for that intersection.
3. The analyst opens the TEAMS Web Portal, selects a map view, and either zooms into the intersection location (if known) or undertakes a Metadata search to query the data available and how to access the data.
4. They select an area around the intersection, and then choose to show the accident rate for that intersection. They select accident history from a menu, and view a listing of the accident records on file. As appropriate, further metadata search of the available data can be made, which will also indicate the data format and how the data can be accessed and displayed. They determine that this intersection does have a relatively high accident rate, and that the accidents have similar characteristics.
5. They then select the project view to see a display of the boundaries of projects in the area over the past five years, and those planned over the next five years. They see that an intersection redesign project is planned, but currently is unfunded.
6. The analyst selects a list of the funded intersection improvement projects in the program, and plots them on a map that overlays the accident rates and traffic volumes. This information is used to delay a lower priority project and fund the intersection redesign project for the intersection where the fatality occurred.

Process #2: Managing and Tracking DDOT Work Requests

The second process flow illustrates how TEAMS would facilitate coordination of work requests across relevant Asset Management systems, and consolidated tracking of both work history and accomplishments for performance reporting. The diagram shows how work requests from the Mayor's Call Center (Hansen

system) would be automatically routed to the appropriate DDOT Asset Management system (e.g. Trees, street lights, etc.) via the middleware product. This product could also (given certain conditions) send email notifications to appropriate parties. When either an externally generated request or an internally generated request is closed in the relevant DDOT Asset Management System, three events are triggered using middleware: the Mayor's Call Center system is updated to close out the request, the TEAMS enterprise work accomplishment data is updated, and a work history record is created, indicating what was done, tagged with the appropriate geographic reference to allow for GIS queries. The example below illustrates the case of a street light request.

Figure 2 Enterprise Work Request Management and Tracking



Scenario 2: Work Flow Coordination – Hansen Call Center and Street Light System

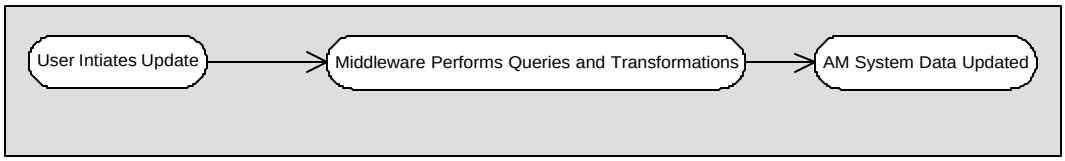
1. Citizen calls to report a street light outage.
2. Incident is recorded in Hansen, which automatically triggers (via middleware) an open ticket in DDOTs (future) web-based replacement to SLIMS (which will be referred to here for convenience as webSLIMS)
3. The open ticket in webSLIMS triggers emails to the relevant DDOT supervisor, and to the contractor responsible for signal maintenance.
4. The contractor makes the repair, and marks the ticket as closed in webSLIMS.
5. This automatically triggers (via middleware) closing the request in Hansen, and updates (1) an accomplishments tracking file, and (2) a work history file which includes a location reference (entered via Hansen or webSLIMS). Note, as part of TEAMS all applications, including contractor owned applications, will be required to include at least one of the location referencing methods supported by DDOT (described in the Task 1 Technical Memorandum).

6. The accomplishments tracking file is used for the weekly DDOT management reporting.
7. The work history information is available within the TEAMS repository for location-based queries and ad-hoc reports.

Process #3: Updating Enterprise Data in Individual AM Applications

This third process illustrates how individual AM Application that make use of enterprise information (i.e. information that is common to several applications) will be updated as this enterprise data changes, via the middleware product. The example provided is for updating the Pontis bridge management system to reflect changes in roadway and traffic information, that is maintained in other systems.

Figure 3 Updating Enterprise Data in Individual AM Applications



Scenario 3: Update of Pontis roadway information

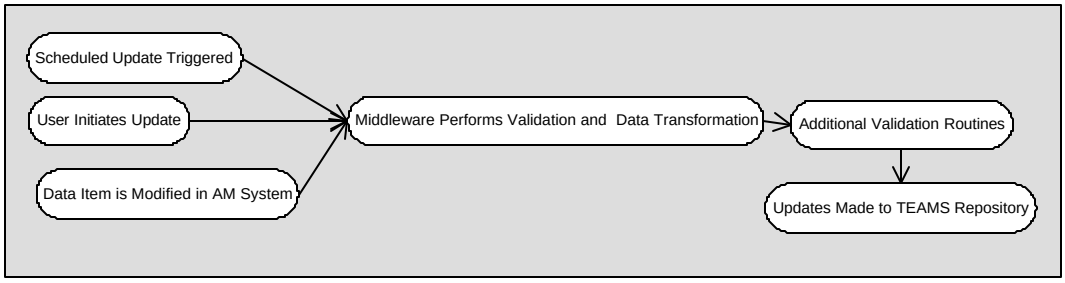
1. Bridge locations with respect to the SIS linear referencing system are established and validated. Both "on" roadway sections and "under" roadway sections are identified for each bridge[4].
2. New traffic data are entered into the traffic monitoring system (or interim file), and AADT's are generated for several routes.
3. Corrections to the number of lanes are made in the street inventory system data.
4. The Pontis system owner requests an update of roadway information.
5. A query is run to update AADT and # lanes for "on" and "under" routes in the Pontis database. (This may be automated or on demand.)

[4] It may be necessary to create a route-system from the linear measures in order to locate the bridges on the roads accurately. The TEAMS geodatabase model includes this functionality. This arises because some of the x/y coordinate data may not be accurate with regard to the road centerlines and the bridges may therefore be offset from the highways. Using linear referencing and dynamic segmentation can resolve this problem without displacing the original coordinates. In effect a dual set of coordinates is created for each bridge reflecting the original and linear location. As an alternative, once the linear coordinates are established the GIS routes can be dissolved and the bridges revert back to simple points rather than point-events (i.e. reverse geocoding of bridge locations). This may have some performance advantages when running queries but the initial step of creating the linear routes will still be required.

Process #4: Updates to the TEAMS Repository

This process illustrates how the TEAMS Repository of Enterprise Information will be updated to reflect modifications in the individual Asset Management applications that are sources of this enterprise information. The diagram illustrates how this updating process may occur on a scheduled basis (e.g. nightly updates), on a user-initiated basis (e.g. after loading new pavement condition into the pavement management system), or on a continuous basis – for time-sensitive information (e.g. status of a work request changes to closed). Three different scenarios are shown below – the first 2 showing simple examples of the scheduled and user-initiated update cases (the instantaneous update process is illustrated in Scenario 2 above for the case of a work request status changing to closed). The third is a complex scenario showing preparation of the HPMS report, which involves both updates of the TEAMS repository from multiple sources, as well as specialized functionality built to support GIS-based processing of information.

Figure 4 Updating the TEAMS Enterprise Data Repository



Scenario 4a: Updating Capital Project Status Information in TEAMS Repository

1. Capital project information is modified in ProTrack's replacement to reflect two projects being advertised, and one project's completion.
2. A regular nightly process is run to extract project status information, check for valid geocoding and valid status codes, and update the information in the TEAMS repository.
3. A user browsing the TEAMS Web Portal the following day brings up a report on recent project activity and sees the three projects, along with their current status and next milestones.

Scenario 4b: Updating Pavement Condition Information in TEAMS Repository

1. New pavement inspection data are loaded into the pavement management system.
2. Data are quality-checked and verified within the pavement management system.
3. The pavement management owner notifies the OSAT TEAMS owner that pavement data is ready for update.

4. The OSAT TEAMS owner initiates an update process, which checks for valid geographic referencing, adherence to enterprise coding, etc.
5. The TEAMS repository is updated, and the new pavement data is available for viewing.

Scenario 4c: Preparation of the HPMS Report

1. HPMS sample sections are established in the TEAMS Geodatabase. A procedure is run to check for uniformity in required HPMS attributes, and produce adjustments to sections if needed.
2. A procedure is run to generate HPMS universe sections that are homogeneous across functional class, quadrant, pavement type, etc.
3. Pavement roughness data is collected and loaded into the pavement management system.
4. Traffic data for all required sections are collected and loaded into the traffic monitoring system.
5. Completed construction project information triggers updates to street characteristics and pavement information (via Middleware).
6. A nightly update refreshes the TEAMS repository with all of the data required for HPMS – including data from the pavement management system and traffic monitoring system.
7. A routine is run to populate HPMS data for sample and universe sections from data in the TEAMS repository. This routine will replace the one currently built in to the SIS HPMS module, and will take advantage of the TEAMS GIS capabilities.
8. The HPMS owner enters remaining information (specific to HPMS; not used in other DDOT systems) into a custom HPMS screen.
9. The HPMS owner selects a standard map view of the data, which indicates where values are missing or invalid. They select a second view that allows for thematic mapping of the values of selected items (e.g. pavement roughness ranges).
10. If erroneous or missing data are found, email alerts are send to data owners listing the location (both HPMS ID and SIS linear referencing data), the data item, and the value. A deadline for data corrections is established.
11. The process is repeated until there are no errors. Finally, the HPMS report is generated from the TEAMS repository and run through the FHWA error checking program.

3.3 DATA VIEW

Purpose and Scope

The data view defines TEAMS capabilities for data management and integration. It includes considerations for how data is to be structured in order to best provide desired functionality and provide desired performance.

Key Concerns

Stakeholder concerns regarding data fall into three categories, described below.

Data Sharing across the Enterprise

- TEAMS needs to establish data standards to facilitate data sharing across different asset management applications. Data standards should consider coding of key attributes such as work type, and asset type that will be used to prepare consolidated views of information from different systems. They also need to specify the options for location referencing.
- Users expressed concern that current inconsistencies in coding may impact the TEAMS vision. The use of middleware to translate across systems is included in the TEAMS vision and can address this concern for cases where translation rules can be defined.
- There is a need for a corporate data model, managed on a continuing basis (i.e. not a one-shot effort) to ensure consistent treatment of entities and attributes across different systems.
- There is a need for a corporate data dictionary to provide documentation of data items in the TEAMS repository, including "crosswalks" to allow for users to understand naming conventions that differ between the TEAMS web portal and the source asset management applications.

Support for Historical Views of Data

- Users want to be able to view historical information about assets, including older versions of GIS representations of these assets (e.g. pavement condition history for a road that has been realigned).

Integrating Data Using Location Referencing and GIS Tools

- Users want to make use of GIS tools for thematic mapping and for location-based queries and analyses. This requires an association of asset attributes to the geographic representations of the assets, and ensuring that the geographic data and attribute data are kept in synch as changes to either occurs.

Ensuring Data Quality, Security, Consistency and Integrity

- Data quality is to be valued more than data quantity.
- Create-Read-Update-Delete permissions need to be established for different users, and business units will need to decide what data is to be shared at these different privilege levels.
- Protocols and requirements need to be established for accepting data into the TEAMS repository.
- The GIS Repository and the geodatabase may need to be set-up to manage different versions of the data that can be integrated as needed.
- Procedures need to be put in place and responsibilities assigned to check data currency and quality.
- A plan for what metadata will be included in the TEAMS repository and how this metadata can be used for understanding data currency and quality.

Level of Effort for Data Collection and Maintenance

- Responsibilities and protocols for updating each data item need to be well-defined.
- Data collection and data entry requirements should be realistic, reflecting likely resources to be available on an ongoing basis.
- Data collection and input methods should be automated to the greatest extent possible.

Assumptions

1. Oracle 9i is the enterprise database management system to be used for the TEAMS data repository.
2. An ESRI ArcSDE Geodatabase will be used for managing spatial and attribute data. The geodatabase will integrate the spatial and attribute data as well as provide the management of the relationship between features.
3. New asset management applications that participate in TEAMS will be required to use either Oracle or SQL Server for their back-end database.
4. TEAMS must support existing asset management application databases, at least on an interim basis.

Key Decisions

1. TEAMS shall support the following linear referencing methods: SIS ID+offset, route ID+offset from beginning of route, street address, and latitude/longitude.

2. The geodatabase design must be compatible with national transportation data models such as NSDI/MAT and UNETRANS; it must be able to capture any routable road segments; it must be able to support multiple applications with multiple versions of centerlines; and it must be able to support the existing centerline model established for DDOT.
3. All location-related data pertaining to assets shall be managed within the TEAMS geodatabase[5]. This includes linear referencing information, length, and route system definitions.
4. Non-location-related attributes pertaining to assets shall generally be managed within individual asset management applications. If there is no other logical home for an attribute that is not location-related, it may be managed within the geodatabase.
5. Asset management applications must include fields for location referencing, such as the SIS ID, to enable mapping of their assets. This is critical for the geodatabase model to link to the remote databases to extract data via the map interface. The TEAMS geodatabase will also contain foreign keys to link back with the asset management databases for synchronizing between the spatial and asset management data.
6. Either automated or manual procedures shall be established to handle cases of asset creation, asset removal, or modification to geographic referencing of an asset to ensure that the geodatabase is kept in synch with the individual asset management databases.
7. A central TEAMS data model and data dictionary shall be developed and maintained on an ongoing basis. This will include all data in the TEAMS central repository. Information about the derivation of each attribute shall be included in the data dictionary.
8. Metadata requirements shall be established for all data in the TEAMS central repository, which includes at a minimum the data source, and date/time of last update. Metadata services shall be established to allow users to determine what data is available, and help them to understand the nature of the data.
9. A master coding table shall be established for data items including but not limited to asset type and work type that will be required for building consolidated views of information from multiple systems. Adherence to these codes shall be a requirement for new asset management systems participating in TEAMS. Modifications to existing asset management systems will not be required.

[5] The term "managed" here means that the geodatabase will be the system of record for the data item, and all updates to the data item will occur within the geodatabase.

10. Translation rules for implementation in middleware shall be established where similar data items are coded differently in existing asset management systems (where possible), in order to meet a TEAMS functional requirement.
11. The TEAMS repository shall support versioning, including historical views of geographic and attribute data, as well as data that has been transmitted, but is pending. All data is to be time-stamped.
12. An enterprise-level data collection, updating and validation / quality checking plan shall be established and maintained for all data items to be included in the TEAMS repository. This plan shall include the data collection method, the work flow process for entering / loading and quality checking the data, the frequency of updating, the data owner, business rules for validity checking, and dependencies on other data items. Where applicable, the method for determining location referencing shall also be specified. This plan shall be reviewed periodically to identify opportunities for streamlined data collection across DDOT.
13. Data updates to the GIS Repository must be performed on a timely-basis, appropriate to the nature of data (how often it changes, criticality) - whether hourly, daily, weekly or monthly.
14. Establish data links to external applications housed in other agencies that DDOT staff interact with, such as the Hansen Call Center, OCTO, EMA, DMV and MPD systems.

View Model

The existing conceptual design of the geodatabase model is included in Reference [2]. As described in that reference, four levels of data structures are envisioned – (1) a base geometry network (defining the basic geographic entities - streets, intersections, rotaries, sidewalks, etc); (2) an Application Reference Network which relate the core geographic entities to route systems used in different applications - for example SIS intersection IDs; (3) a Location Reference Network which includes definitions of routes built from the application reference network information (e.g. truck routes), and (4) a data event layer which defines the locations of entities like projects, pavement sections, bridges, accidents, or traffic counts based either on the location reference network or the application reference network.

3.4 CONSTRUCTION VIEW

Purpose and Scope

The Construction View is concerned with how TEAMS software will be built - what components are needed, and what principles will be followed to ensure that the different components work together.

Key Concerns

The following concerns related to the Construction View have been expressed by TEAMS stakeholders:

- The DOS-based SIS application modules need to be replaced.
- Web interfaces for asset-related data update are needed to support multi-user access, particularly where both contractors and DDOT staff need to be updating the same database.
- The COTS acquisition timeline is out of synch with TEAMS development. There is a need for technical specifications in the short term to guide COTS selection and purchase.
- Asset Management applications need to be compatible with the selected middleware solution. Criteria for compatibility of asset management applications with the TEAMS architecture must be clearly stated in order to provide guidance for current and future efforts to evaluate and acquire new/updated systems.
- There is a need to ensure integration between the asset management applications and the geodatabase. For new applications, specific location referencing information (compatible with an established Application Referencing Network) needs to be included. For existing applications where location data is not included, a strategy for incorporating this data for future upgrades needs to be established.
- There is a need for rules and guidelines for external contractors who manage data and applications, including data collection, such as VMS.
- Metadata service for the construction of the TEAMS components is required. This will include a description of the applications, their configuration requirements, coding and other programming standards, data format, published API (to SeeBeyond) and other information pertaining to the software integration.
- Given limited resources, TEAMS needs to accommodate existing legacy applications, even if they do not include open API's.
- TEAMS architecture needs to be extensible in order to accommodate future applications yet to be defined.

- There is a need to define how external systems will be integrated into the TEAMS architecture – e.g., data and applications outside of the firewall, including other DC data warehouses.
- Where possible, DDOT OSAT would like the flexibility to make modifications to applications in-house.

Assumptions

1. Business units will remain owners of their business data and support applications. However, in order to ensure that the data and applications can be integrated, OSAT will establish guidelines and provide technical support to assist business owners with selection decisions. They will also continue to provide technical support for application installation and integration.
2. Commercial-Off-the-Shelf (COTS) products are preferred over custom software development, though custom development will be considered for portions of TEAMS where no suitable COTS product exists.
3. The SeeBeyond e*Integrator middleware will provide connectivity across asset management applications (where needed), and between asset management data and the central TEAMS repository. System connectivity is to be established though open Application Programming Interfaces (API's) from each of the system applications that will be a part of TEAMS. If applications have open API's, these API's can be used by SeeBeyond technology to read and write data between systems. For business units that want to be more restrictive in editing privileges, the APIs can be set to read only.
4. ESRI GIS software will be used (ArcSDE, ArcIMS, ArcReader,ArcView8, ArcEngine).
5. All applications must run under Windows 2000 OS.
6. Existing/planned asset management applications to be integrated as part of TEAMS: Azteca (Trees), Hansen Call Center, SERVES, Trans*prt preconstruction modules, MicroPaver, Pontis, iSLIMS, new Traffic Signal Management Database (TSMD), Curbside Master Database (CMD), TMS/H, Hansen Permitting, Utility Works Notification System, White Ticket.
7. Existing applications to be replaced or upgraded as part of TEAMS: SIS Pavement/Roadway, SIS Administrative Classifications, SIS Traffic, SIS HPMS, SIS curbs, SIS sidewalks, TARAS, ProTrack, Pavement field data collection, Constra.
8. New asset management applications under development to be integrated in the future: Culvert Management, Tunnel Management, Alley Management.
9. Financial systems (SOAR/EIS/PASS) to remain as-is, external to TEAMS, though TEAMS may access selected financial data.

Key Decisions

1. A GIS maintenance and analysis sub-system shall be developed, which will provide a set of tools for management of the geodatabase, specialized mapping and spatial analysis. This will include some "out-of-the-box" capabilities, and some custom development. These tools will be accessible via a desktop GIS client.
2. A GIS query and reporting application shall be developed to provide a user-friendly interface and set of tools for thematic mapping, and location-based queries. This application shall be part of the TEAMS web portal, and shall be accessible via a desktop GIS client as well.
3. A commercial reporting package (to be determined) shall be used to develop standard reports and to provide end-users ad-hoc reporting capabilities via the TEAMS web portal. This package shall support development of both tabular and graphical reports.
4. The TEAMS architecture shall support data query via the GIS and SeeBeyond middleware. It shall be designed to support a web services approach in the future.
5. Specific criteria shall be adopted and published for new applications to be acquired, updated or developed and incorporated within TEAMS. These criteria shall ensure compatibility of the application with the DDOT's middleware solution (open API), supported databases (Oracle and SQL Server), GIS architecture (inclusion of location referencing information, compatibility of any built-in GIS functionalities with the TEAMS geodatabase approach), operating system (Windows 2000), and software architecture (web-enabled).
6. A technical review panel shall be established to provide support to business owners in evaluating COTS products for compatibility with TEAMS.
7. TEAMS shall on an interim basis incorporate existing windows-based legacy applications where needed and where feasible, even if they do not meet the criteria for new applications.

View Model

The TEAMS architecture diagram (Figure 2 in Reference [3]) provides the current construction view of TEAMS. This diagram is to be revised to show all of the existing asset management applications, and identify which applications will be replaced or upgraded, and to provide a further breakdown of the construction of the web portal and geodatabase maintenance elements.

3.5 DEPLOYMENT VIEW

Purpose and Scope

This view is concerned with the deployment of TEAMS – including additional hardware and networking capabilities that need to be in place to support implementation; migration of existing data and applications, installation considerations, business process changes, and training. Given that TEAMS is still at an early phase of its development, this view does not attempt to quantify infrastructure or staffing requirements. Rather, it emphasizes identification of the deployment issues that may impact the system architecture, and/or that need to be considered at a more detailed level in future phases.

Key Concerns

Deployment-related concerns of stakeholders are listed below.

Business Process, Training and Documentation

- Changes to business processes, roles & responsibilities will be required in conjunction with TEAMS implementation. Planning for these changes needs to be an explicit part of the TEAMS project. Specific concerns include:
  - Need to market the TEAMS project internally to obtain stakeholder and user buy-in into the process.
  - Helping stakeholders to understand how TEAMS is going to affect their day to day responsibilities and activities.
  - Frequent communication about TEAMS status and implementation is essential.
- Training of TEAMS end users is critical to the success of the project. Resources need to be set aside to develop training materials and conduct training – both for initial rollout of the system, and for ongoing training (as people, roles and responsibilities change). TEAMS stakeholders raised the following specific concerns regarding training:
  - Need for good continuous and easily available training; particularly in the use of GIS software.
  - Positions may have to be reclassified to account for new skill sets needed in the TEAMS framework.
  - DDOT workforce development training should be focused on retaining the current workforce and build on their knowledge, expertise, and experience through training in the required skill sets.
  - The concept of 'Streamline' training was introduced, whereby a suite of several job-related training courses at different proficiency levels are available. Staff should be able to configure a training program suited to

their job needs, by selecting and combining from a menu of available training courses.

- Online training materials and computer-based training (CBT) would be valuable.

Hardware/Software Infrastructure Needs

- TEAMS will likely require additional investments in hardware in order to provide an acceptable response time to users, provide sufficient storage space for the data, ensure that the data are kept secure and ensure that the system can be scaled up to meet likely future needs. Key considerations to be addressed are:
  - Server capacity and redundancy
  - Network Capacity (bandwidth, latency, redundancy)
  - Network Security (Firewall, Intrusion Detection capability)
  - Network and Systems Management capability
  - Performance tuning for databases and network
  - Data Backups and Preservation (Tape backup capacity and speed, including on-line backup, and data replication capability)
  - Disaster Recovery capability
  - Scalability – accommodating future growth in capacity and performance demands in a gradual fashion, without requiring the infrastructure to be re-architected.

Data Migration

- As legacy systems are replaced, plans for data migration and archiving of historical data need to be developed. These plans need to include verification procedures to ensure that the migrated data are complete.

Installation Considerations

- The installation and roll-out process needs to be designed to minimize disruption.
- The amount of software to be installed on individual client machines should be kept to a minimum in order to facilitate both the initial installation process, and the ongoing processes for distributing software patches and upgrades.
- Where software must be installed on individual client machines, remote installation scripts should be used to automate the process.

System Administration

- TEAMS will require additional database administrator (DBA) and system administrator effort.

Assumptions

1. Training and support requirements for individual asset management systems are to be defined by business owners responsible for these systems. These are considered to be outside of the scope of TEAMS.

2. The TEAMS IT infrastructure will be based on the existing network architecture composed of the following interconnected networks operated and maintained by the DDOT NOC data center:

- **DC WAN:** The OCTO Geodatabase, located at a remote location (Judiciary Square) on OCTO servers will be accessed via the D.C. WAN, maintained by OCTO. Internet connectivity for DDOT is provided through the DC WAN via fractional T3 and redundant T1 circuits.
- **DDOT LAN:** The Hansen Call Center Database and other TEAMS applications located at the DDOT in-house data center at the Frank E. Reeves Municipal Center, will be accessed via the DDOT LAN, maintained by DDOT.
- **DDOT WAN:** The TEAMS asset management applications, hosted at remote DDOT sites and remote DDOT clients, will be connected and accessed via the DDOT frame relay cloud. The DDOT WAN infrastructure is based on Frame Relay T1, SMDS, and redundant ISDN circuits.
- **DDOT NOC and Data Center:** DDOT currently has its own data center, shared with the Department of Public Works (DPW) at the Frank E. Reeves Municipal Center. While the two departments are currently in the process of splitting their IT infrastructures so as to be completely independent of each other, it is expected that they will both continue to host their respective infrastructures within the same data center. New TEAMS servers will be hosted out of the same data center.

3. Networks are expected to be operational at 50% of the peak bandwidth capacity 99.5% of the time, 75% of peak bandwidth 80% of the time. A maximum network latency of 3 seconds is assumed on the DDOT LAN.

4. A comprehensive systems and network management tool will be put in place to enable NOC staff to proactively and reactively monitor and manage the various network equipment, servers and storage within the data center.

5. Network-level security via a department router and firewall (along with redundant counterparts for fail-over purposes) will be in place to impose the necessary level of network isolation and provide an additional layer of network address translation for the TEAMS web portal.

6. The firewall will have VPN capabilities to provide support staff access to the servers and networking equipment from off-site locations.
7. OSAT will assign trained and qualified staff responsibilities for database administration and system administration and maintenance.

Key Decisions

1. Regular communication regarding the TEAMS project shall be established via web pages and electronic newsletters to keep stakeholders informed, provide access to relevant documents, and provide opportunities for feedback.
2. The TEAMS design phase should include development of detailed use cases which describe how users will interact with the system. These use cases should build upon the stakeholder needs identified in Phase I and be developed with extensive stakeholder involvement.
3. A central TEAMS helpdesk shall be established, providing telephone and email support for the TEAMS web portal and any asset management system issues that may be related to the middleware functionality.
4. Any modifications or upgrades to asset management applications must be coordinated with OSAT, as they may impact established TEAMS application and data integration functions.
5. A training course will be developed and offered to TEAMS users regarding use of the TEAMS web portal.
6. All personnel responsible for data input and quality checking related to TEAMS (i.e. data considered to be enterprise information and made accessible via the TEAMS web portal) will be trained in proper procedures. Cross-training will be provided in order to limit dependence on particular individuals.
7. An installation and roll-out plan for TEAMS will be developed in consultation with the DDOT Data Center and NOC personnel.
8. Database backups procedures will be put into place,, consistent with established DDOT OSAT practices.
9. TEAMS will have the following operational and performance requirements:

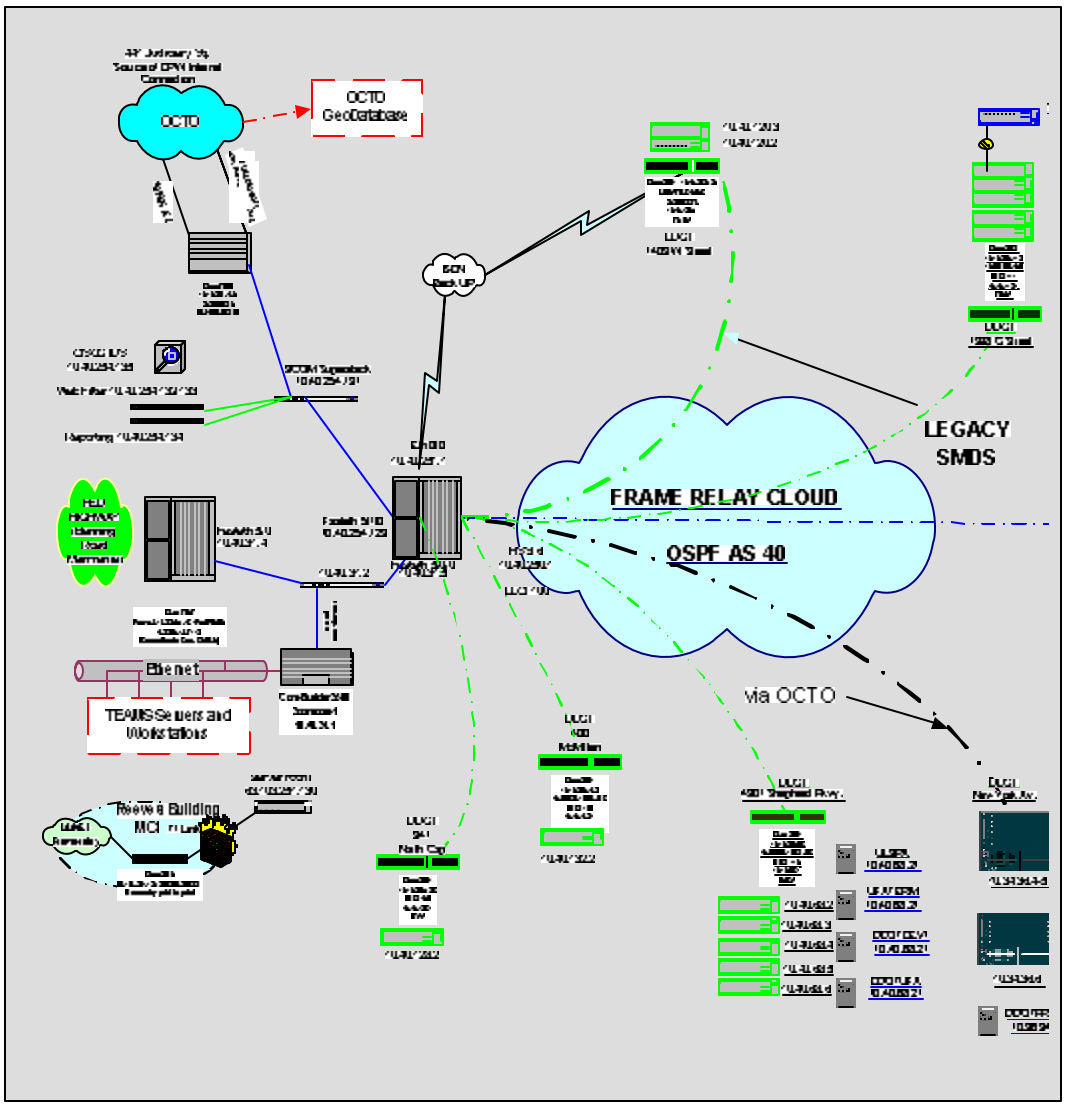
- Within regular DDOT business hours, there shall be no scheduled down time for the TEAMS servers. If hardware or software problems occur requiring the infrastructure to be taken off-line, the system will not be down for more than 3 hours. On a monthly basis, the target availability during regular business hours is 95%. In order to provide this level of reliability, redundancy should be built into the TEAMS infrastructure (servers, networking equipment) to the maximum extent practicable.
- The TEAMS servers will be operational outside of regular DDOT business hours (24 X7), but regular maintenance and backups may be scheduled

during the off-peak hours, so continuous access to the Web Portal and databases will not be guaranteed. Users shall be kept informed about the times of scheduled maintenance so that they can plan accordingly.

View Model

The following diagram illustrates the infrastructure on which TEAMS is to be deployed.

Figure 5 DDOT Network Infrastructure [To be replaced with DDOT Campus Network Infrastructure (Reeve's Center) diagram]



4.0 Issues Tracking

Table 2 TEAMS Architecture Issues and Comments Tracking

Issue	Initiator	Assigned To	Status	Resolution	Date
1.To what extent should TEAMS address external data sharing issues?	Stakeholder Workshop 10/30/03 – Services View		Closed	Requirement added for TEAMS to include links with external applications.	12/8/2003
2. To what extent should TEAMS provide a public portal into DDOT data?	Stakeholder Workshop 10/30/03 – Services View		Closed	Assume that TEAMS will include some publicly accessible data; but may be lower priority than internal DDOT functionality (included as a "may" requirement)	12/8/2003
3. Will all queries from the TEAMS web portal draw upon TEAMS repository information, or will live queries to asset management applications also be supported?	CS		Closed	Requirements drafted to allow for live queries – to be further explored in the Design Phase	12/8/2003
4. How will FileNET repository be related to the TEAMS repository?	CS		Closed	FileNET can include geo-references; DDOT examining GTI's IDM product to link FileNET to GIS and enable users to query documents by location – to be further investigated in the design phase.	11/14/2003
5. Will FileNET	CS		Closed	To be	12/8/2003

Issue	Initiator	Assigned To	Status	Resolution	Date
documents be accessible from the TEAMS Web Portal?				determined in conjunction with issue 4 in the design phase.	
6. What work flow automation is to be accomplished via FileNet vs. SeeBeyond?	CS		Closed	All work flow-related requirements assume use of SeeBeyond. FileNET workflow to be further investigated in design phase.	12/8/2003
7. Section 2.1 TEAMS Stakeholders – should address DDOT's end users which are internal and external. Internal users: Engineers, Operational managers (project managers), OSAT (Spatial Data Systems, Applications Support, PMO). External Users: Other DC Agencies, Federal Agencies e.g. Federal Highway, Citizens. Each level of users has specific needs for TEAMS. Their needs should be explicitly documented.	DDOT	CS	Closed pending DDOT review of Draft Final	Expanded sections 2 to discuss the specific user groups.	12/8/2003
8. Page 2-7: The System Support Staff need to understand the big picture of how the system works, including system components, data flow, work flow and end results.	DDOT	CS	Closed pending DDOT review of Draft Final	Section 2.2 edited to reflect these needs.	12/8/2003
9. Page 3-8: Services View key concern – the list of variety of information pertaining to the location that users want should	DDOT	CS	Closed pending DDOT review of Draft Final	Added to Services View Key Concerns	12/8/2003

Issue	Initiator	Assigned To	Status	Resolution	Date
include: - park services – DC and National - Right of Way - Bridge History - Historic District - Trees - As Built Drawings -Third Party liabilities for damaging DC properties					
10. The iSLIMS referred to under Scenario 1 is a contractor-owned system. Please investigate more and generalize the workflows between Hansen and any contractor that may be handling the transactions for DDOT.	DDOT	CS	Closed pending DDOT review of Draft Final	The original document was referring to a planned DDOT application that was never completed. The scenario description was modified to specify a future DDOT web-based application, which is the intended approach for DDOT-contractor coordination on work tracking.	12/8/2003
11. Page 3-15: Item 7 under Scenario 3 is not done by DDOT.	DDOT	CS	Closed pending DDOT review of Draft Final	The current SIS HPMS application (to be replaced with TEAMS GIS-based functionality) takes information from the SIS source tables, and generates aggregated and transformed data for HPMS sections. This is the activity described in this	12/8/2003

Issue	Initiator	Assigned To	Status	Resolution	Date
				step. The term "calculation" was replaced with "populate" to avoid confusion.	
12. Page 3-16: Scenario 4: Use of the TEAMS Web Portal: Metadata search should be included in the workflow so that user will know what's available and how to access the data.	DDOT	CS	Closed pending DDOT review of Draft Final	Added text	12/8/2003
13. Page 3-16: Remove "per VMT" contained in item 4 under Scenario 4. Also, Metadata search should be included…	DDOT	CS	Closed pending DDOT review of Draft Final	Made edits as suggested	12/8/2003
14. Page 3-18: The view model (work flow processes) should contain all scenarios possible in all of the DDOT Administrations.	DDOT	CS	Closed pending DDOT review of Draft Final	Added 4 generic work process flows applicable to all DDOT administrations; examples illustrate specific scenarios for these process flows	12/8/2003
15. Key Decisions (for Data View): External data link should be included, since DDOT users interact with other agencies data servers such as Hansen, DMP, MPD, EMA and OCTO.	DDOT	CS	Closed pending DDOT review of Draft Final	Interaction with these external data sources was added to the key decisions section.	12/8/2003
16. Page 3-21: Construction View – Key Concerns: Metadata service construction should be included.	DDOT	CS	Closed pending DDOT review of Draft Final	Added metadata service to key concerns.	12/8/2003
17. Hardware/ Software	DDOT	CS	Closed pending	Added bullet to Hardware/	12/8/2003

Issue	Initiator	Assigned To	Status	Resolution	Date
Infrastructure Needs: Performance Tuning (for both databases and network) should be included.			DDOT review of Draft Final	Software Infrastructure Needs	
18. DDOT Network Infrastructure: DDOT Campus Network Infrastructure (Reeve's Center) diagram should be included (can be obtained from SEAT group).	DDOT	CS/DNS	Open – to be provided in next draft.		
19. Include a Glossary of Abbreviations and their meaning	DDOT	CS	Closed	Added Glossary to front matter	12/8/2003